



# **Commercial Crew Program Status**

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# Agenda



- Commercial Crew Program (CCP) Highlights and Progress
- CCP Top Program Risks
- Boeing Summary
- SpaceX Summary
- Sierra Nevada Corp. Summary
- Blue Origin Summary
- Mishap Coordination
- Summary



# Highlights



## **CCP has made significant progress over the last quarter, notably:**

- **Continue to burn down key certification products with the providers**
- Over 90% of the alternate standards are completed
- Over 60% of the variances are completed
- Over 60% of the Phase 2 hazard reports are completed
  
- **Eight CCP missions now in process:**
- For SpaceX:
  - August 2017: Flight to ISS Without Crew (Demo Mission 1)
  - November 2017: Flight to ISS with crew (Demo-2)
  - PCM-1 awarded November 2015; Completed two milestones to date
  - PCM-2 awarded July 2016; Completed one milestone to date
- For Boeing:
  - June 2018: Orbital Flight Test (unmanned demo)
  - August 2018: Crewed Flight Test (demo)
  - PCM-1 awarded May 2015; Completed four milestones to date
  - PCM-2 awarded in December 2015; Completed two milestones to date



# Program Progress



**CCP has made significant progress over the last year, notably:**

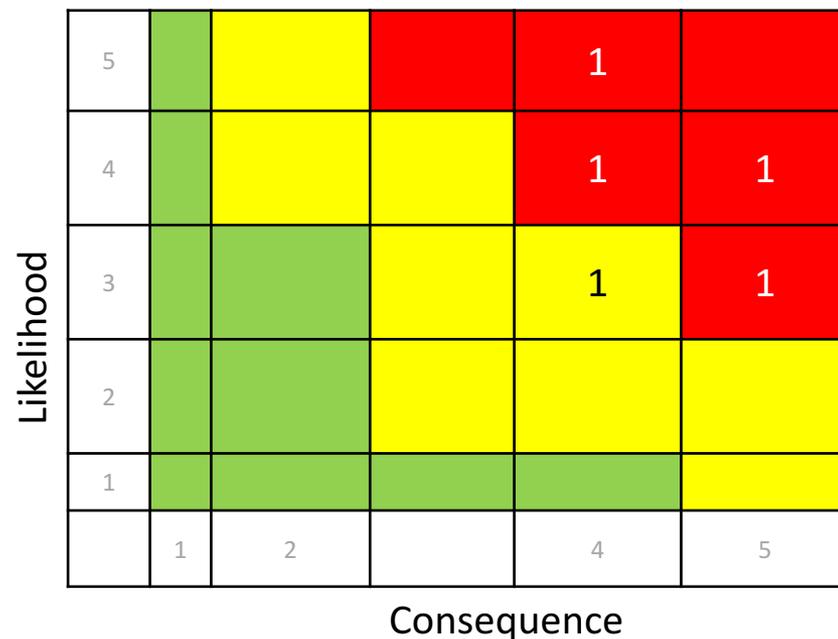
- **Awarded Post Certification Missions 1 & 2 for both providers**
- Developed procurement strategies for the remaining PCMs
- **Certification and CoFR planning and execution**
- Updated and approved program Certification and CoFR plans
- Developed and gained approval of strategy and Cert CoFR statements through the agency stakeholders
  
- **Evolved Risk Management process to delineate crew safety risks**
- **Partnered a MOA with four NASA centers for consistent and stable Engineering support**
- **Obtained Government Astronaut legislative change**
- **Started engaging with International Partners**
- **Negotiated spectrum usage with the FCC and DOD**
- **Successfully implemented and completed Cross-Center supervisory pilot program**



# CCP Top Programmatic Risks 10/27/16



LxC	Trend	Risk Title	Risk ID Number	Office
4x5	NC	Requirement Changes	CCP-PCI-2015-3	PC&I
5x4	NC	DOD Search and Rescue Posture	CCP-GMO-2015-3	GMO
4x4	NC	Ammonia Emergency Response	CCP-SC-2016-3	SC
3x5	NC	Ability to Close the LOC Gap	CCP-SEI-2015-1	SE&I
3x4	NC	DoD Search and Rescue Training Schedule	CCP-GMO-2015-4	GMO



**NOTE: “Programmatic” risks include cost, schedule and technical consequences**

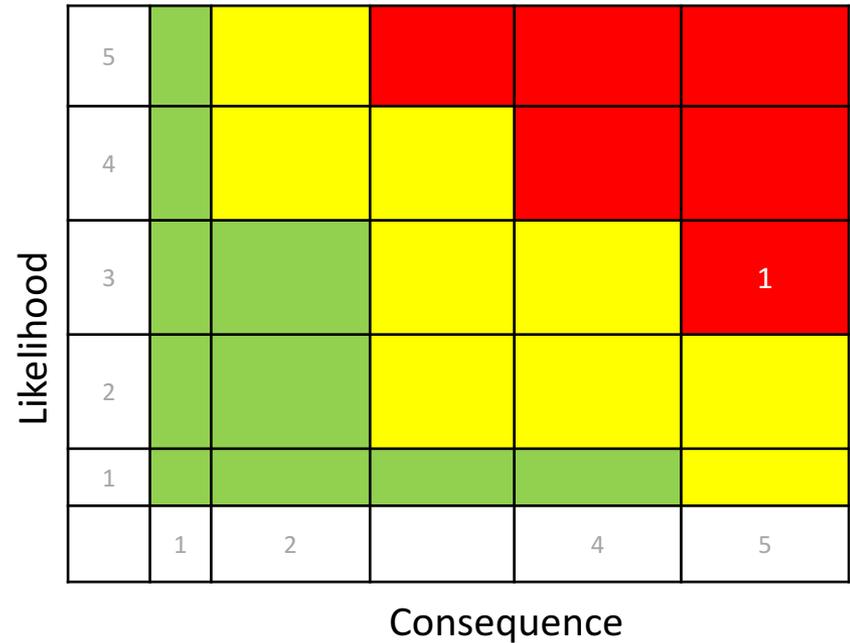


# CCP Top Program Safety Risks

## 10/27/27

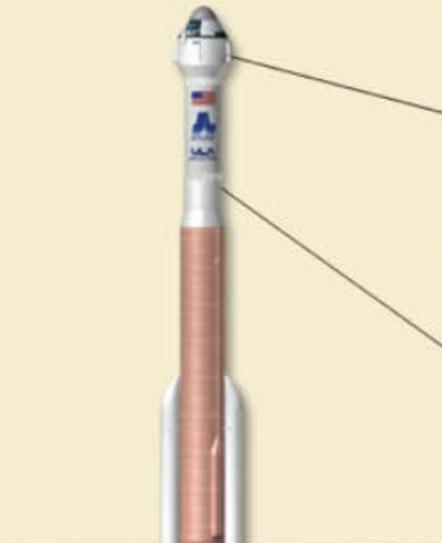


LxC	Trend	Risk Title	Risk ID Number	Office
3x5	NC	Ability to Close the LOC Gap	CCP-SEI-2015-1	SE&I





# Boeing Architecture Description



## Spacecraft Segment

Simplicity of design with high maturity through use of existing technologies within Boeing and from our key suppliers such as Aerojet Rocketdyne and General Dynamics

- Crew Module
- Service Module
- Flight Software

## Launch Segment

Mature design through use of heritage design, production, and operations from our key supplier ULA

- Launch Vehicle
- Launch Pad
- Launch Control Complex
- Pad Test and Checkout
- Spacecraft / LV Integration
- Emergency Detection System

## Ground and Operations Segment

Mature design and processes through use of proven Boeing production techniques

- Cargo Integration
- Assembly, Integration and Test Facility
- Landing and Recovery
- Landing Site Facilities
- Network Services

Mature mission operations through use of heritage mission support from our key supplier JSC/Flight Operations Directorate (FOD)

- Crew Training
- Mission Control Center
- Mission Planning
- Training Systems
- Mission Operations



# Boeing Accomplishments



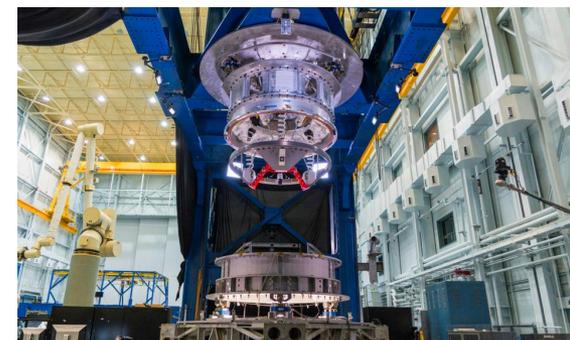
- **Design**
- Heat Exchanger delta CDR complete
- Ascent & Entry Suit CDR: Nov 15

## Demonstration & Test

- Wind Tunnel Testing of Launch Vehicle Adapter skirt design tested
- International Docking Adapter and NASA Docking System tested at Johnson Space Center
- Launch Abort Engines with new propellant valves hot-fire development testing complete
- RL10 hot-fire acceptance testing of OFT/CFT engines complete
- Landing airbag qualification testing at Langley Research Center complete
  - Additional tests scheduled to validate crew impacts
- Crew Module propellant tank qualification testing complete
- Arc Jet tests at Ames Research Center



Wind Tunnel Tests



Docking System Tests



Launch Abort Engine Tests



RL10 Acceptance Tests



Landing Airbag Tests



# Boeing Accomplishments

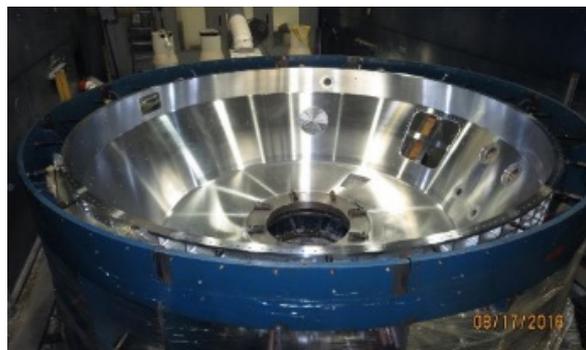


## Production & Qualification

- Structural Test Article Crew Module testing targeted to begin in October
- Spacecraft 1 Crew Module upper and lower dome outfitting in work
- Spacecraft 1 Service Module structural panels at Kennedy Space Center
- Service Module Hot Fire test vehicle in production
- Spacecraft 2 and 3 progressing across supply base
- Crew Access Arm and White Room installed on Crew Access Tower at Cape Canaveral Air Force Station's Space Launch Complex-41

## Facility Preparations

- Work progressing at White Sands Test Facility
- C3PF Hazardous Processing Facility build in work





# SpaceX System Description



## Spacecraft Segment (Dragon)

- Crew Dragon
- Trunk
- Launch Abort System (internally integrated in Dragon)

## Launch Segment (Falcon 9)

- Full thrust Merlin engines
- Densified propellants (chilled LOX & RP-1)
- Common First stage w/Falcon Heavy design
- Autonomous Flight Termination System
- Landing legs (stowed in ascent)
- Stage separation system

## Ground and Operation Segment

- Launch Operations System
  - Launch Pad (LC39A), Launch Pad facility, Ground SW, & Launch Control Center
- Mission Operation System
  - MCC (Hawthorne) Crew Ops, Training & Sim, & Recovery



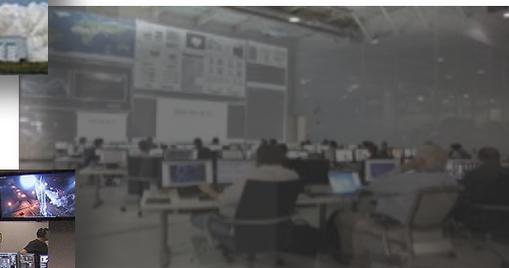
Falcon 9



Crew Dragon Vehicle



Launch Control  
Cape Canaveral, FL



Mission Control  
Hawthorne, CA



LC-39A  
Kennedy Space Center, FL



# SpaceX Accomplishments



## Certification Products

- Certification plan approved
- Alternate standards nearly 100% complete
- Verification Events closures in work
- Hazard analysis proceeding and on track for 100% delivery this quarter

## Design

- Completed Delta Critical Design 2
- Drawing released for qualification space suit; suit is currently in test
- Dragon and Falcon 9 designs baselined and under formal change control
- LC-39A crew interface designs and demonstrations are on track for Launch Site Operational Readiness Review

## Demonstration & Test

- Completed test series with initial Dragon propulsion test module
- Completed 6 full thrust F9 flights with load & go operations with densified propellants
- Completed 4 key parachute drop tests and on track to complete full test series
- Multiple Space Suite test units complete and on track for full qualification
- Multiple Environmental Control and Life Support System (ECLSS) test units complete and on track for full integrated test
- Qualification capsule first round structural testing complete and ongoing qualification on track
- Completed multiple propulsive landing tests



Parachute Test Weight Sled



Hardware In The Loop Avionics Test Bed



Parachute Testing



# SpaceX Accomplishments



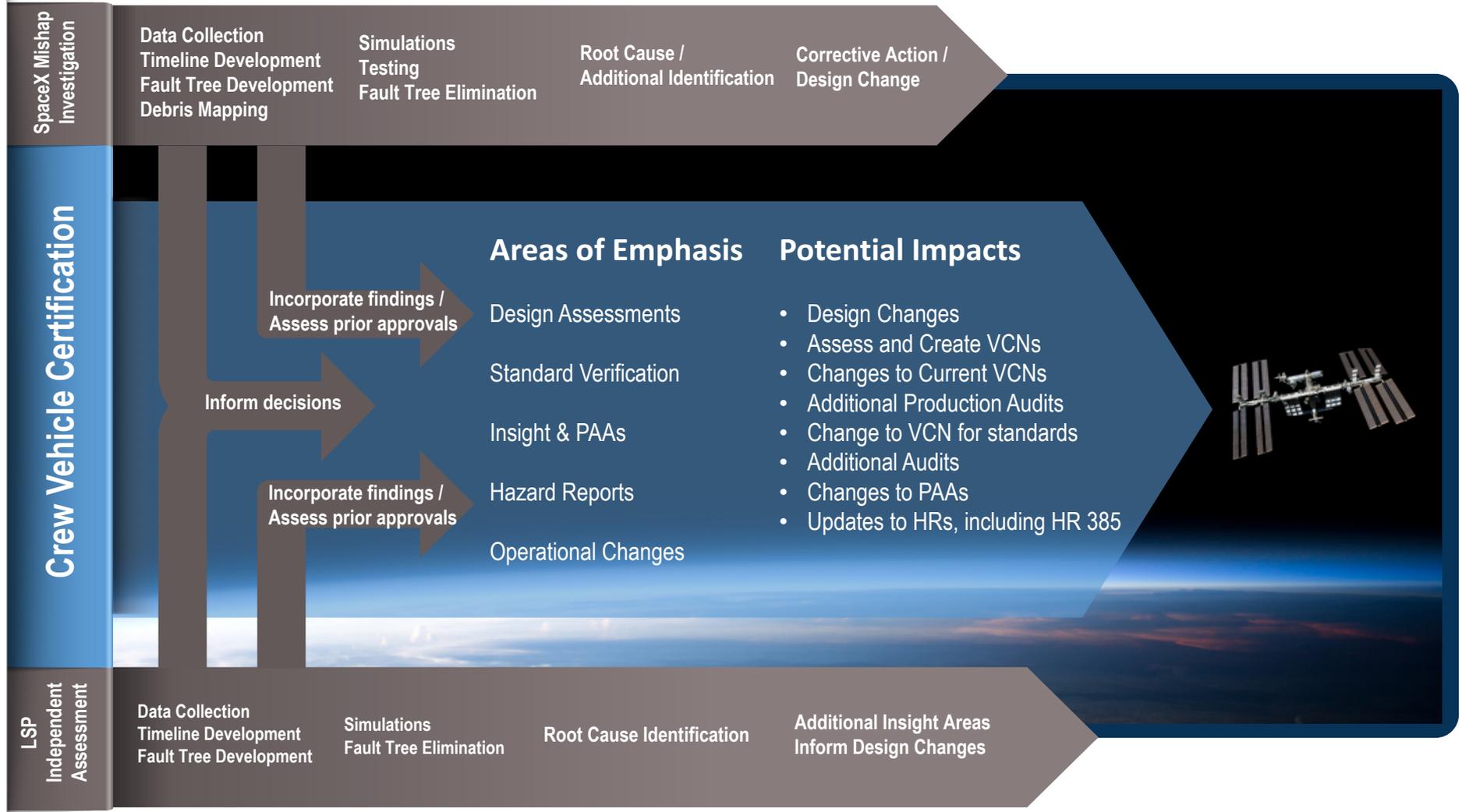
## Production and Integration

- 4 Crew Dragon capsules in parallel production
- Qual test capsule weldment fabrication complete; outfitting for upcoming qual tests
- ECLSS test capsule weldment complete; multiple ECLSS components complete & installed
- Demo 1 capsule weldment complete; capsule in next stage of production
- Demo 2 capsule weldment in work
- Multiple components across Dragon, F9, and updated ground systems completed or entering into qualification phase and on track for implementation





# SpaceX Mishap Coordination



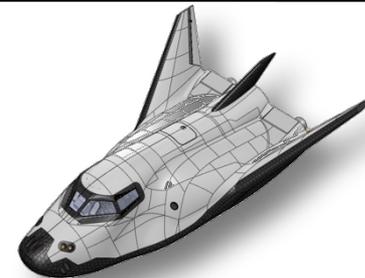


# Sierra Nevada Corp. Accomplishments



## Approach & Landing Test 2 (ALT-2) is CCiCap Milestone 4B and CRS2 Integration Milestone 5

- Full scale *Dream Chaser*® engineering test article (ETA) unpowered approach & landing test (ALT-2)
  - Ship to AFRC Q1 2017 for Range and Taxi Testing then Approach & Landing Test 2
  - Primary Objectives:
    - Collect subsonic aerodynamic data to validate wind tunnel and CFD aero results
    - Validation of spacecraft low-speed aerodynamic flying qualities – stability and control
    - Validate subsonic orbital vehicle flight software and GN&C functionality.



## Key Dream Chaser test vehicle Activities, Q3-Q4 2016

- Successfully executed a large number of offline, on-vehicle and integrated tests in Louisville, CO facility to verify system design requirements and validate system function.
- Landing Gear tests identified nose/main landing gear (NLG/MLG) deploy sequence issue
- Remaining work planned in Colorado before Jan 2017 ship to AFRC/EAFB
  - Complete Landing Gear hydraulic system modifications and acceptance testing
  - Avionics Checkout with Flight Fault Tolerant Flight Computers using Flight Software ver. 3.0 (flight load)
  - Polarity Test, Multi-Actuator Test, pre-Ship Day-In-The-Life Test, Radar Altimeter installs, Flush Air Data System Checkout, Rollout Ground Resonance Test
  - Prep ETA for ship before Christmas, Ship to AFRC/EAFB 1<sup>st</sup> week January 2017



**Execute Free Flight Test (ALT2) March 2017, complete milestone NLT Aug 2017 (current CCiCap 5-year period of performance).**





# Blue Origin Accomplishments



## No Exchange of Funds Space Act Agreement

- Accomplishments
  - Held multiple TIMs
    - Astronaut Seat Design
    - Flame Diverters
    - Corrosion Control
    - Enterprise Software
  - NASA leadership invited to witness in-flight escape test
- Data Exchange
  - Various software requests and technical documentation exchange in work.
  - Manufacturing consulting request
- Look Ahead
  - Milestone Review #2, Progress Review of *New Shepard* Subscale Propellant Tank, scheduled for November 7 at Blue Origin's Kent, Washington facility
  - Continuing technical interchange



*New Shepard* in-flight escape test (October 5, 2016)



# Summary



## **Boeing and SpaceX are advancing their design concepts**

- Actively building and testing hardware to inform design
- Engaging in meaningful insight with NASA
- Addressing important design challenges

## **Both providers are providing increased insight opportunities for the NASA team**

## **CCP has robust and efficient processes for certification including addressing waivers and deviations**

## **In preparation for flight, there is significant work ahead**

